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The role of coccinellids (Coccinellidae) in suppression of the number of *Aphis craccivora* Koch, 1854, and *Aphis gossypii* Glover, 1877

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Abstract
The paper contains information about some bioecological and ethological peculiarities of 7-spot ladybird playing a significant role in regulation of number of Cotton Aphid and Cowpea Aphid in cotton growing regions of Azerbaijan. In the conditions of agrocenosis we identified about 10 species of predatory and parasitic insects involved in limiting the number of aphids in the fields: 7-spot lady beetle (*Coccinella septempunctata*), Adonis' lady beetle (*Adonia variegate* G.) from family Coccinellidae, *Chrysopa carnea* St. from family Chrysopidae; *Syrphus corllae* F., *Scaeva albomaculata* M. from family Syrphidae; *Aphidius ervi* Hal., *Praon volucre* H., *Diaeretiella rapae* M. from family Aphididae, etc. From predatory insects the most widespread and effective species are coccinellids, particularly 7-spot lady beetle. Large voracity of larvae and adults of lady beetles play an important role in reducing the number of cotton and cowpea aphids. Thus, the results of studies have shown that the use of lady beetles against aphids has great ecological and economic values.

Keywords: *Aphis craccivora, Aphis gossypii, Coccinella septempunctata,* biology, ecology, bioregulation

1. Introduction
From various methods for agricultural pest control the biological methods and integrated programs providing the maximum reduction in the use of pesticides are particulary important [1]. Application of the biological method completely eliminates the danger of poisoning of plant pollinators, pest and people with toxic substances. Entomophages suppress outbreak of existing pest and simultaneously give no chance to new ones. This method is economically more profitable than chemical method and other ones. In the cotton-growing regions of the republic from pests of agricultural crops the black and cowpea aphids annually cause great harm [2]. In suppression of the number of these cotton pests an important role belongs to entomophages, among which the coccinellids are of most importance. The paper contains the results of long term research on revelation of the species composition of the most important natural enemies of aphids damaging cotton, definition of useful role of economically valuable species living under the conditions of agrocenosis, studying of their biological and ecological peculiarities.

2. Material and Methods
Collection of material and field works were carried out in the cotton fields of Sabirabad district of Azerbaijan (2012-2015). Laboratory studies were performed in the laboratory of Ecology and Physiology of Insects of the Institute of Zoology, National Academy of Sciences of Azerbaijan. Species composition of coccinellids was detected according to beetle collections and systematic surveys of cotton fields and grassy vegetation. For species definition the beetles and other aphidophagous coccinellids were kept in the laboratory in glass jars with 1-3 liters in volume and in special plexiglas cages.
Under natural conditions, coccinellids were studied on the cotton bushes under gauze insulators. Census of predators and aphids was carried out daily on 3 bushes damaged by aphids (aphids on points, and predators by the number).
To study the possibility of parthenogenetic development in coccinellids, after hatching females were kept in the separated glass jars without males. Laid eggs were placed in individual jars to avoid eating them by females.

To study the influence of various factors on survival of larvae they were kept in individual jars at different temperature and food conditions. To study the fertility of Coccinellidae a couple of male and female beetles were placed in a separate jar and fed on aphids. The number of eggs laid in the egg mass was counted daily.

In order to study the beetles' voracity each of them was kept in a jar separately and was fed on pre-counted aphids. A day later the remaining aphids were counted. The newly hatched larvae were placed in individual jars and fed daily on a certain number of aphids till the pupation. The time of molts was registered at the same time. And it gave the opportunity to learn the voracity of larvae of each age.

To clarify the number of generations per year one pair of beetles was kept on the plant together with aphids under the insulator. After oviposition beetles under insulator were taken and watched the development of larvae and pupae till the hatching of adults of the next generation.

All experiments were conducted at least three or five replications

3. Results and Discussion

Many researchers [3-14] studied the biology, ecology and distribution of different species of lady beetles, but the studies on relationships in the predator-prey system on the example of sucking pests of cotton (Cotton Aphid and Cowpea Aphid) and Coccinellidae (7-spot lady beetle) have not conducted before our researches.

7-spot lady beetle hibernates in nature under dead leaves, near the roots of weeds, under clods of soil, etc. In wintering areas they gather in small groups of 10-20 and more individuals.

Spring come out of hibernation occured in the second half of April, with an average daily temperature of 11.3-13.5 ^{0}C and a relative humidity of 55-75%. Emergency time of beetles coincided with the beginning of flowering of early ripening fruit and wild plants. After hatching, they met at various flowering herbs growing among the cotton fields and around them.

During this period the number of aphids on plants is very small and beetles fed on pollen, nectar of flowers of various plants.

It is established, that the number of lady birds in the cotton fields during the season is depends on the degree of infestation of plants by aphids, as well as weather conditions.

Coccinellids in cotton fields appeared in the spring with the emergence of cowpea aphids on plants. Maximum number of lady beetles found on cotton in mid-May, when the cotton aphid moved to cotton. During hot periods when reproduction of aphids on cotton was depressed, the coccinellids and other aphidophags migrated to other plants, where at that time there were aphids (from 10 July to 25 August) occur. Starting from the end of August the number of coccinellids in the cotton fields was increased, provoked by increasing numbers of aphid and cotton bollworm eggs on plants.

Fig 1: Coccinella septempunctata

Females of lady beetles lay eggs only 8-10 days after the supplementary feeding on aphids. Females can lay unfertilized eggs. The first egg clusters were observed by us on April 25-27 and May 5-7 at the camel thorn and cotton. Duration of oviposition was 28-45 days.

Duration of egg development in coccinellids was closely related to environmental temperature. At an average daily temperature of 17-18^{0}C the eggs were developed 6-8 days and at 25-27^{0}C the development was finished during 3-5 days.

Larval development depended on the temperature and dietary factors and lasted between 7 and 13.5 days. Lady birds had four larval stages. The pupal stage lasted from four to 7 days depended on the temperature and humidity.

Lady birds completed the development of one generation during 21-24 days in May, 16-18 days in June and 18-20 days in September.

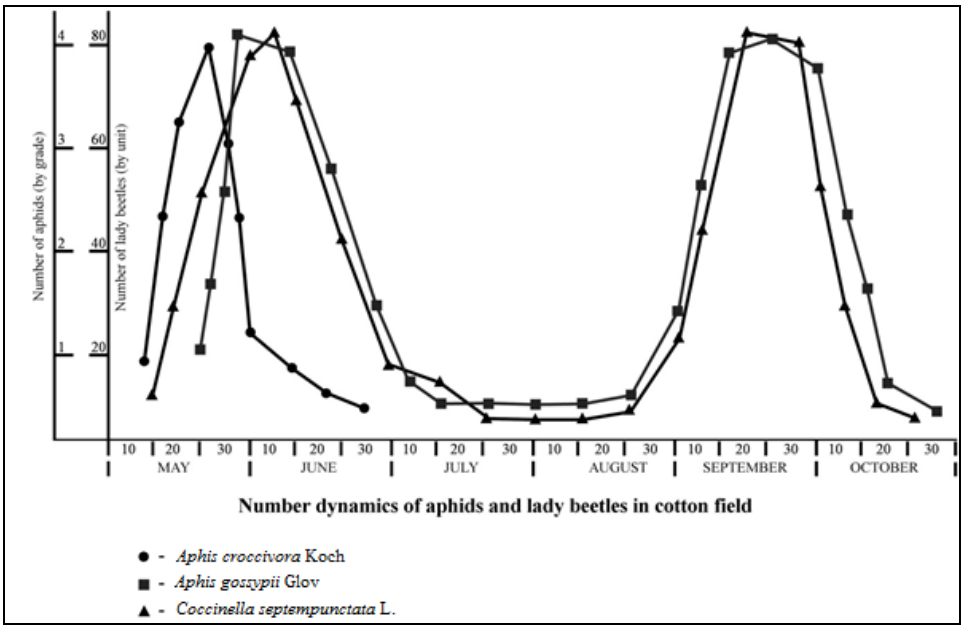
Beetles of II generation were registered in mid-June, and III generation beginning from the second half of September. Beetles of III generation went into hibernation since November.

Productivity of females was closely related to dietary factors and weather conditions, and ranged from 216 to 980 eggs (Table 1).

Dry and hot summer negatively effects on the population dynamics of aphids, which in turn dramatically reduces fertility of coccinellids.

Studies on voracity of adults showed that over a lifetime the male and female of overwintered generation of 7-spot lady bird was eats averagely 4124 of cotton aphid and 4215 of cowpea aphid, and the next generation 3985 and 4012 respectively. Four instar larvae killing averagely 55-60 cowpea aphids daily and 250-330 cowpea and 260-320 cotton aphids during 8-9 days turned to be more voracious (table 2).

Beetles emerging from pupae in the first two days were inactive and they killed 10-30 aphids per night, then their voracity is gradually intensified. During mating and egg-laying period the voracity again decreased, and then it rose sharply.



It is clear from results obtained that the abundance of aphids in the cotton agrocenoses was depressed by representatives of families of Chrysopidae, Syrphidae and Aphididae. However the seven-spot ladybird (*C. septempunctata*) from the family Coccinellidae also plays great role in the regulation of number of aphids. So, 30-35% of entomophages and 50-55% of predators in agrocenoses was amounted by *C. septempunctata*.

Table 1: Productivity of the 7-spot lady beetle *Coccinella septempunctata*

Species of prey	Data of census	Generations	Average duration of egg laying(days)	Number of eggs laid by a female		
				Min	Average	Max
Cotton Aphid	May	Hibernated	29,1	216	367,8	509
	June-July	1st generation	45,2	481	635,1	767
	September-October	2nd genera-tion	41,0	412	708,4	980
	Averagely per year	Total	38,4	369,7	570,4	752
Cowpea Aphid	May	Hibernated	28,7	218	372,4	519
	June-July	1st generation	42,8	492	649,5	801
	September- October	2nd genera- tion	43,1	442	698,2	926
	Averagely per year	Total	38,2	384	573,4	748,7

Table 2: Voracity of larvae of the 7-spot lady beetle on different species of aphids.

Aphids	Generations	Average number of aphids killed by different instars larvae				Totally consumed	The average duration of development (days)	The average daily temperature for the period of development (°C)
		1	2	3	4			
Cotton Aphid	1st (May)	29,4	33,8	64,2	136,6	264,0	13,2	18,3
	2nd (June)	38,2	42,4	78,2	156,9	315,7	8,6	23,2
	3rd (September)	32,5	40,1	66,0	149	287,6	9,1	22,5
Cowpea Aphid	1st (May)	27,3	33,4	51,8	132,6	245,1	12,9	18,4
	2nd (June)	31,6	53,3	79,6	163,7	328,2	8,4	23,5
	3rd (September)	26,3	49,1	78,3	166,0	319,7	8,9	22,4

The abundance of ladybirds in the cotton fields surrounded by alfalfa fields was more than other areas by 15-17%. It was connected with the abundant groups of hibernating *Aphis craccivora* Koch the main food of coccinellids in these areas. Overwintered *A. craccivora* outbreaked in early spring and gave 2-3 generations in the alfalfa fields. Then it migrated to the cotton fields and caused great damage to cotton.

As it shown from the diagram there was a cynchonization between the predator and prey density dinamics. An increase in *A. craccivora* density eventually resulted in a higher *C. septempunctata* rate. This shows the effectiveness of the *C. septempunctata* in control of aphids.

Sometimes the beetles waked up in the middle of winter. We observed it in 17-18 February when the weather was sunny and the temperature was 18-20ºC. Ladybirds began to go out of tree bark, wall cracks and other shelters and look for food. When there were no aphids for them to eat they went to sleep again.

The researches showed that the high temperature (higher than 24-28 ºC) negatively effects on reproductive ability of seven-spot ladybird. The optimum temperature for its development is 20-25 ºC and the humidity is 65-70%. The fluctuations of this regime influence the biological indices of the seven-spot ladybird.

It should be noted that the molting process of the seven-spot ladybird occured in groups consisted of 5-10, sometimes 30 specimens.

Taking into consideration the above mentioned we set a goal to develop the best ways for artificially breeding and using of *C. septempunctata* in bio and agrocenoses (particularly in greenhouses).

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